

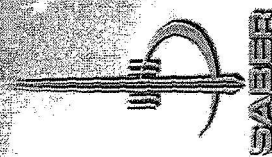
ISS Commercial Cargo Service: Requirements & Constraints Summary

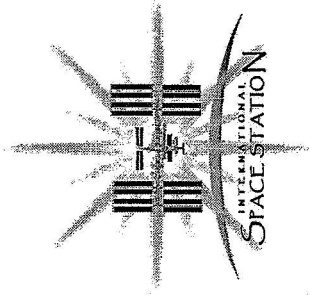
**ISS Commercial Cargo Service
Industry Day Conference**

April 25, 2005

**Valin Thorn
Neil Lemmons
Matt Scheutz**

ISS Strategic Planning & Requirements Office
<http://saber.isc.nasa.gov>
281.244.7097





Purpose & Agenda

Purpose

Present preliminary ISS Commercial Cargo Service (ICCS) requirements

Agenda

Background

Philosophy

Cargo Balance

Internal Cargo Balance

External Cargo Balance

Water Balance

Gas Balance

Return Cargo

Cargo Types

ICCS Flight Rate

Late & Early Access

Power to Payloads

Mating Location Options

ISS Docking & Berthing

Vehicle Stay Time

ISS Resource Availability

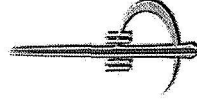
Robotic & EVA Compatibility

Return Cargo

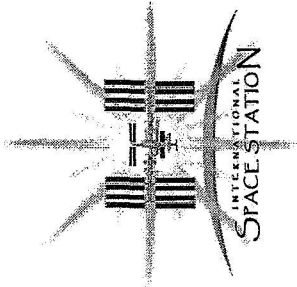
Key Req's Summary

Conclusion

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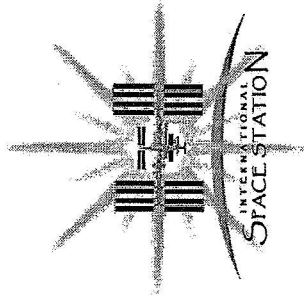


Background

- *ISS commercial cargo transportation services will compensate for some cargo lost from Shuttle retirement in December 2010*
- *The NASA Launch Services Program Office (LSPO) at KSC is leading the acquisition effort with ISS assistance*
- *ISS preliminary requirements provided to LSPO (March 15th) for ICCS Draft RFP preparation*
- *ICCS requirements revision expected before Draft RFP release*

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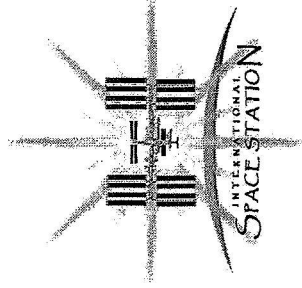
Philosophy

Service vs. Spacecraft Acquisition

- ***NASA is acquiring a service, not spacecraft***
- ***ISS requirements for integration of visiting vehicles included***
 - ◆ ***Prox ops, docking, berthing, robotics, interfaces, attached operations, resource availability, safety, etc.***
- ***ICCS annual cargo needs specified – maximum and minimum levels***
 - ◆ ***Minimum level to help set contract firm commitment with options for additional service***

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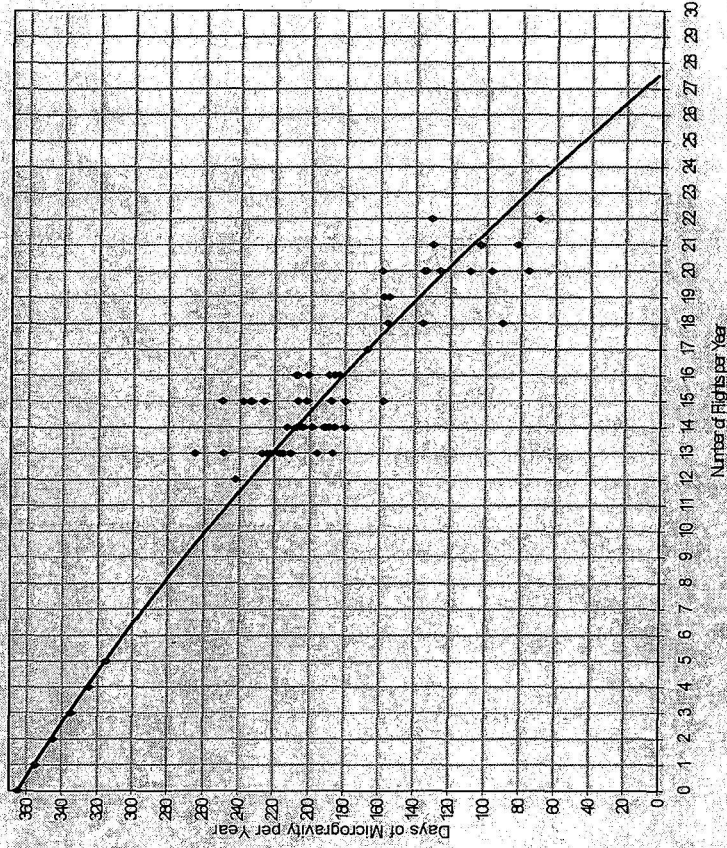




ICCS Cargo Vehicle Flight Rate

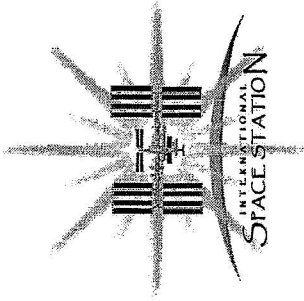
- ICCS vehicle flight rate limited to 6 flights/year
 - ◆ Crew time impact for arrival and departure operations
 - ◆ Impact to micro-g operations, still important to ISS partners
 - ◆ Soyuz, Progress, ATV, HTV vehicles visit 10 to 12 times / year in total
- ICCS must be able to respond to a cargo service request within 180 days
 - ◆ Unexpected need for crew supplies, maintenance, utilization, etc.

Trend Data for Days of Microgravity as a Function of Number of Flights



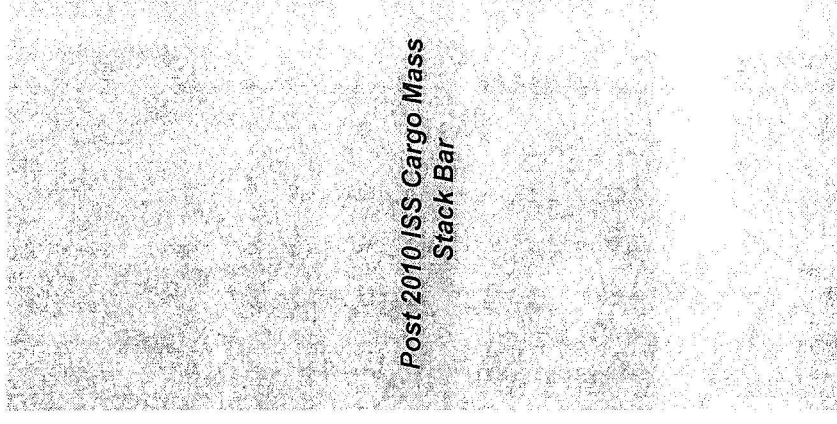
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ISS Cargo Categories

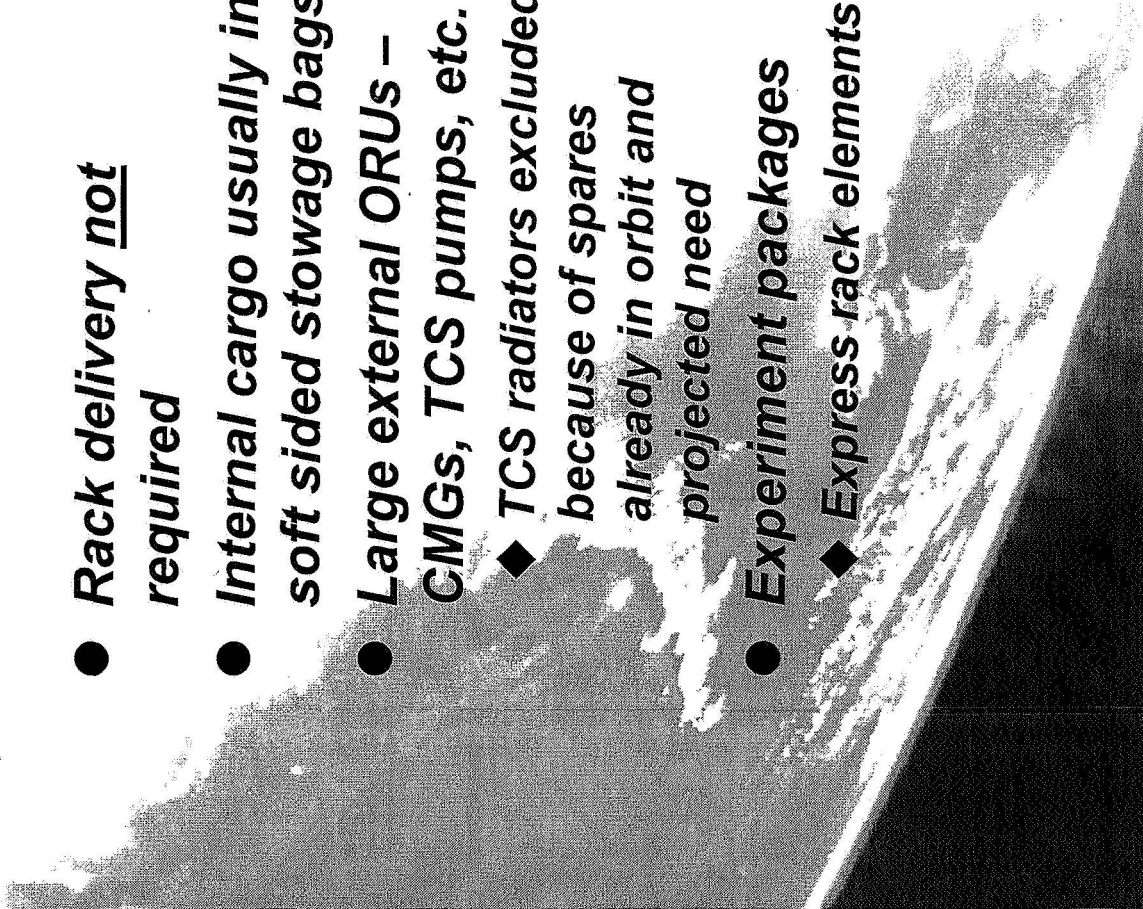
- **Assembly hardware**
 - ◆ **Not ICCS requirement**
- **Crew Supplies**
 - ◆ **Food**
 - ◆ **Water**
 - ◆ **Gas**
 - ◆ **Flight crew equipment**
- **Maintenance**
 - ◆ **Internal & external ORUs**
 - ☞ Preventative and corrective maintenance
- **Utilization/Research**
 - ◆ **Research equipment, experiments**
 - ◆ **Laboratory consumables**

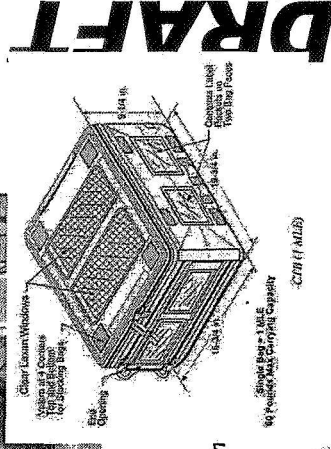


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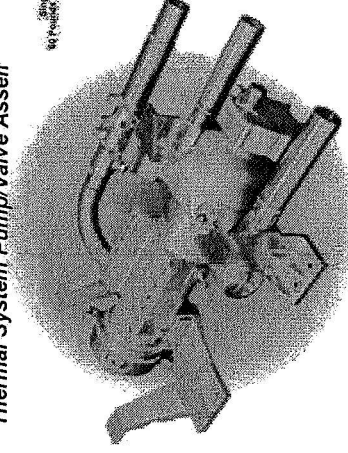




- 
- **Rack delivery not required**
 - **Internal cargo usually in soft sided stowage bags**
 - **Large external ORUs – CMGs, TCS pumps, etc.**
 - ◆ **TCS radiators excluded because of spares already in orbit and projected need**
 - **Experiment packages**
 - ◆ **Express rack elements**

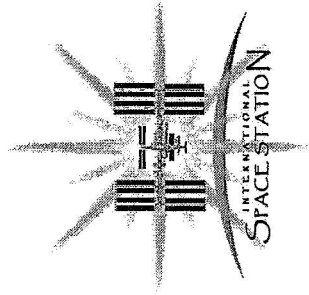


Thermal System Pump/Valve Assen



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Late and Early Cargo Access

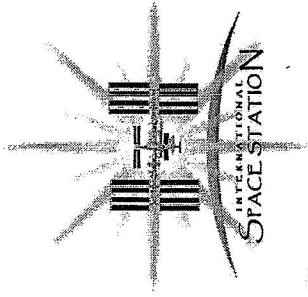
- Various payloads, such as plants and animals require late loading into the cargo vehicle
 - ◆ Cargo service/vehicle should provide cargo access as late as 19 hours before launch
- Returning payload specimens and samples will need to be removed from the cargo vehicle shortly after landing
 - ◆ The cargo service/vehicle should provide the capability to remove the payload from the cargo vehicle within 4 hours after returning to Earth



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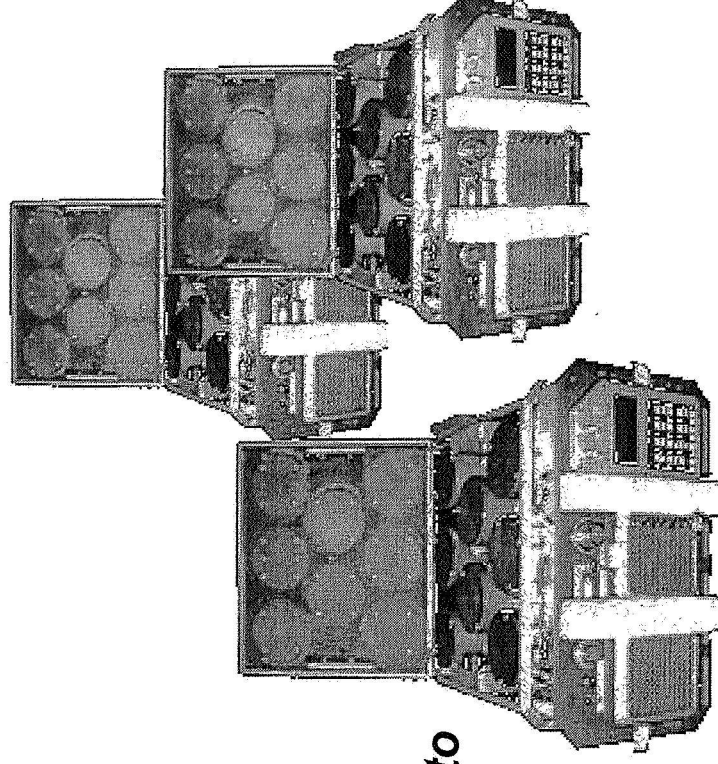


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Power to Payloads

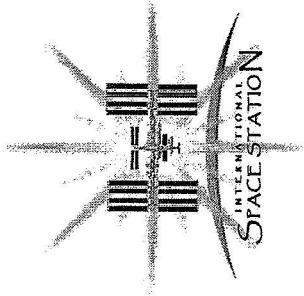
- ICCS payload power requirements during transportation
 - ◆ 500 W average
 - ◆ 1500 KW peak
 - ◆ Return power assumed to equal delivery power needed



Example Payload:
Commercial Generic Bioprocessing
Apparatus

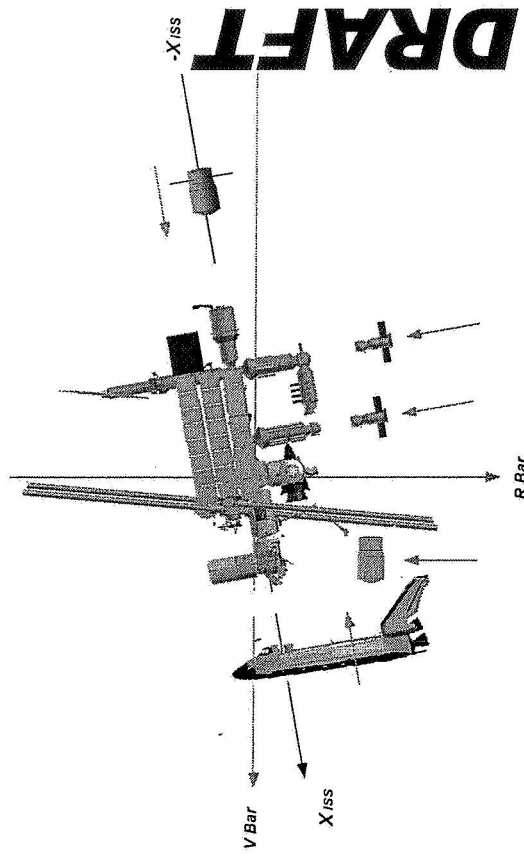
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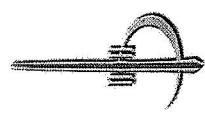


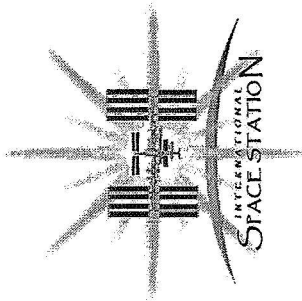
ISS Rendezvous, Prox Ops, Docking, Berthing Aids

- No existing automated rendezvous & docking system to US segment
 - ◆ ISS only provides visual aids for Shuttle prox ops/docking
 - ◆ ICCS provided AR&D system for ISS is an available solution option
- HTV automated rendezvous to robotic capture and berthing
 - ◆ DGPS & TCS navigation
 - ◆ R-Bar approach to ISS nadir capture box – robotic berthing to Node 2 nadir
- Soyuz, Progress, and ESA ATV vehicles use Russian RF based, rendezvous & docking system
 - ◆ Applicable for dockings to ISS Russian segment
 - ☞ Service Module (SM) aft
 - ☞ SM/Docking Compartment nadir
 - ☞ FGB nadir



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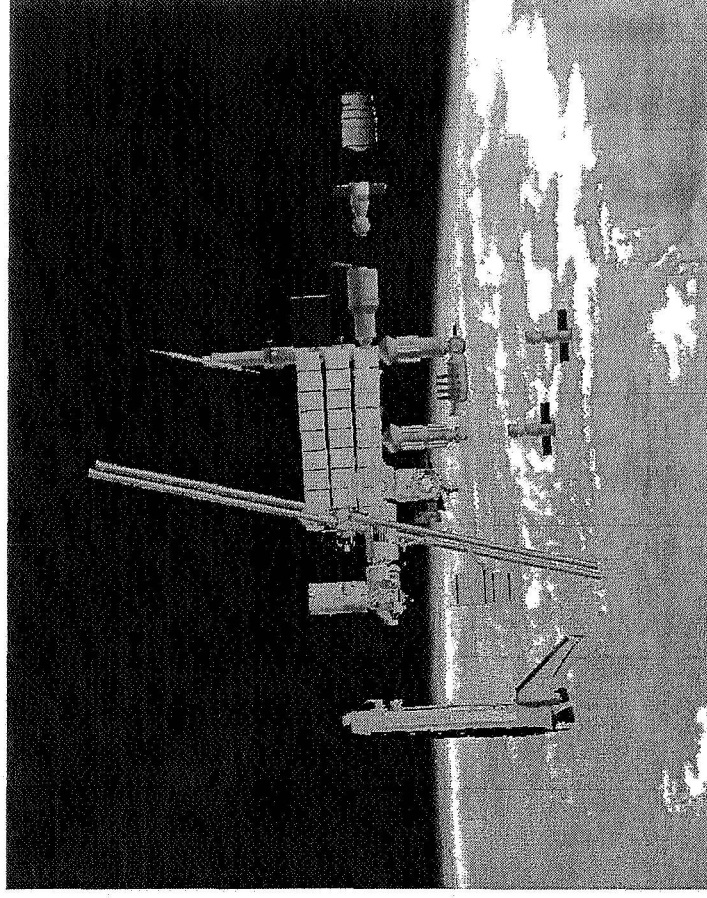


ISS Flight Attitude

- ICCS vehicles must dock and mate with the ISS in its normal operational flight attitude

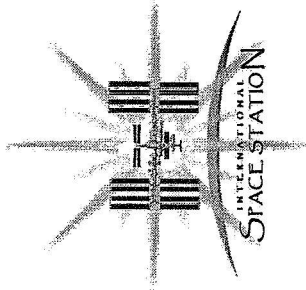
◆ X W Z Nadir TEA

- ☞ X body axis on velocity vector
- ☞ Z body axis down/nadir
- ☞ TEA – Torque Equilibrium Attitude



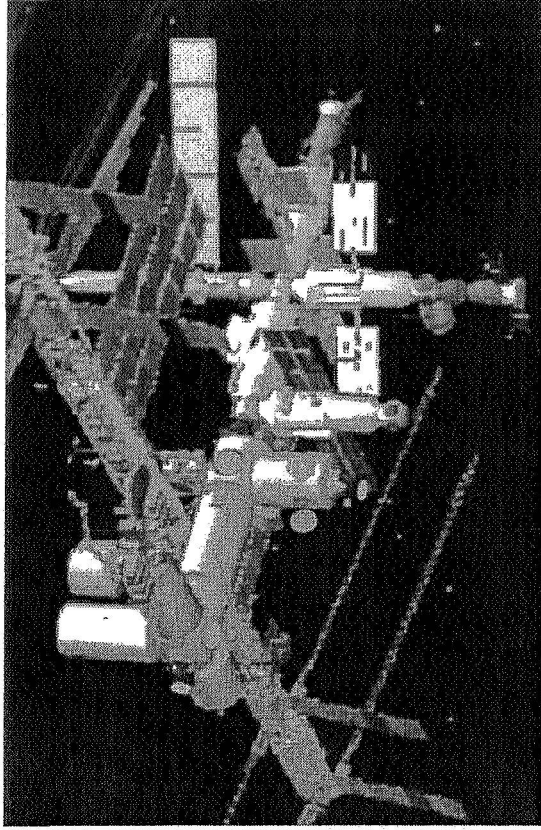
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ISS Mating Location Options

- ISS has six candidate ports available for attaching ICCS vehicles
 - The ports on the Russian Segment will be occupied continuously with Soyuz, Progress, and ATVs
 - Additional vehicles can visit these ports but will decrease the docked time of the Progress and ATV
- The US Segment's ports have low occupancy rate
- Attaching to the US Segment offers more flexibility

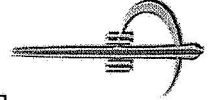


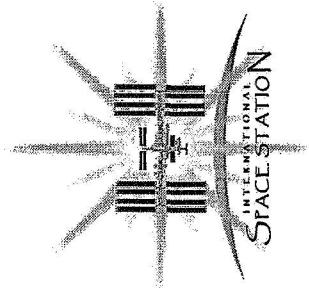
ISS Vehicle Traffic & Port Utilization

Post Shuttle Refinement Example

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
SIM Att	P1	P2	P3	ATV								
SIM Nadir FGB Nadir	Soyuz A	Soyuz B	Soyuz C	Soyuz D								
Node 2 Nadir Node 2 Fwd												
Node 3 Fwd												
Node 3 Port Node 3 Stbd												
Node 3 Nadir												

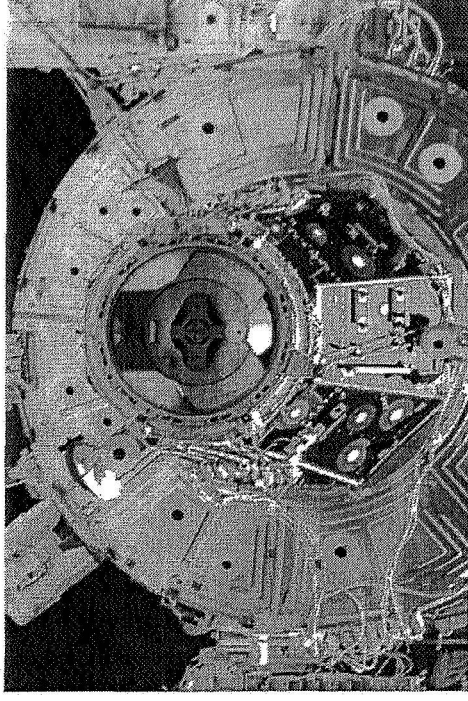
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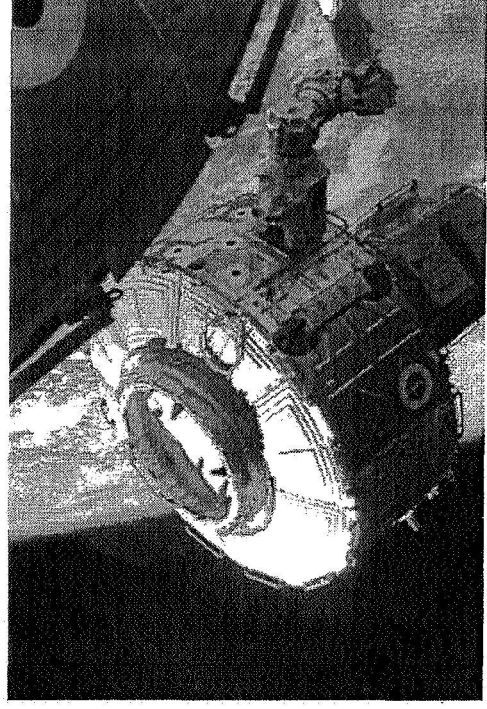


ISS Docking & Berthing

- ISS dockings to US Segment use Russia's Androgynous Peripheral Attachment System (APAS)
 - ◆ +X Body: PMA2
 - ◆ +Z Body: PMA3
- ISS module interfaces use Common Berthing Mechanisms (CBMs)
 - ◆ ISS robotic capture & mating only
 - ◆ MPLM, HTV

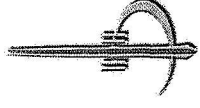


APAS on PMA

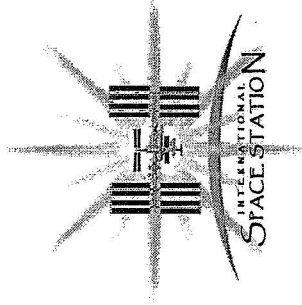


CBM on Airlock Module

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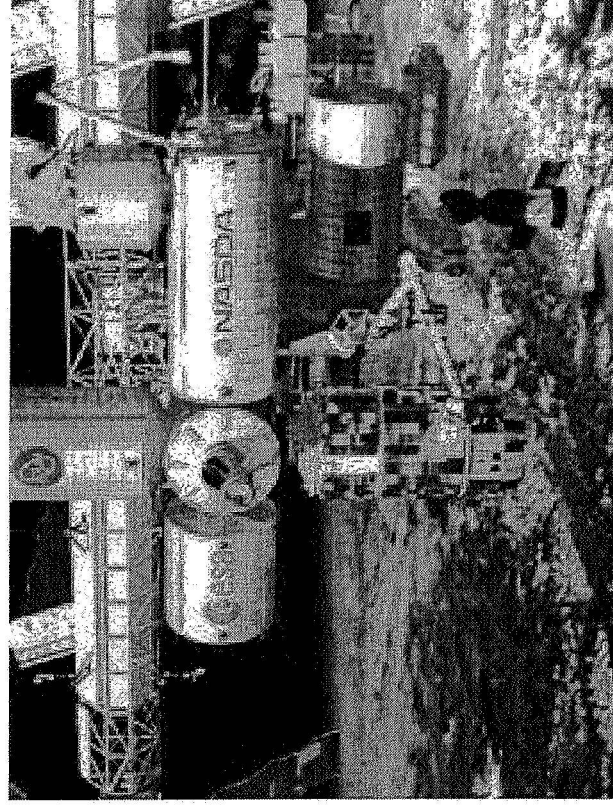


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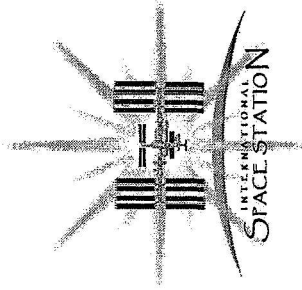
Vehicle Stay Time

- ***ICCS vehicles must be capable of staying at the Station at least 7 days***
 - ◆ ***Minimum time required to handle cargo transfer operations***
 - ◆ ***Results of recent HTV studies may increase this minimum time***
- ***Maximum stay time dependent on ISS operational vehicle traffic and port utilization plans***
 - ◆ ***Longer stay time improves operational flexibility***



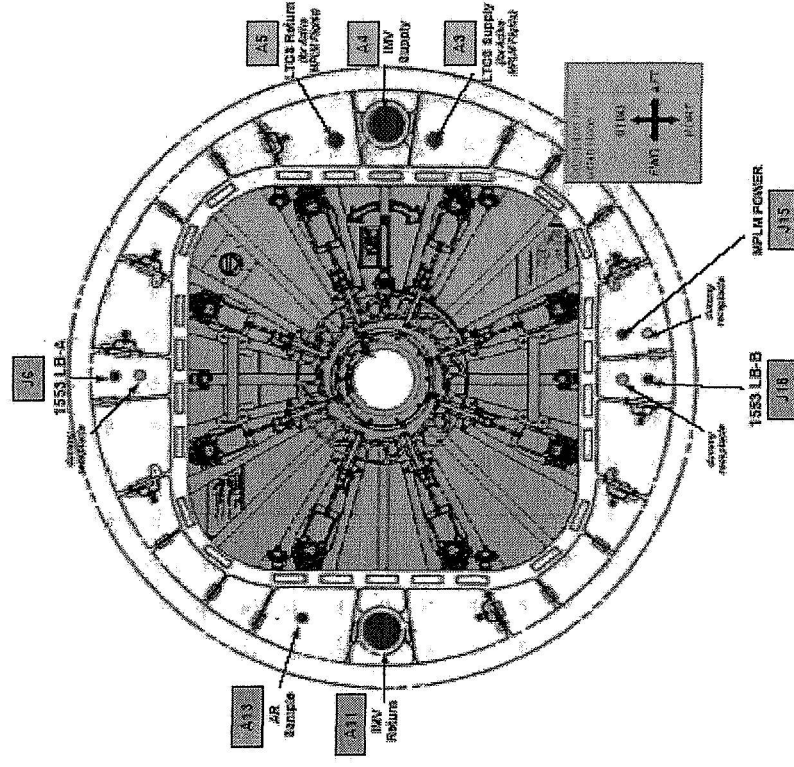
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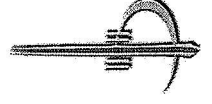
ISS Resources for ICCS Vehicles

- **Power**
 - ◆ Allocation of 500 W average, 1500 W peak for ICCS
 - ◆ Typically 3 KW capacity
- **Thermal**
 - ◆ Thermal water loops available at Node 2 Nadir, Node 3, and Node 1 port side CBMs
 - ◆ ~ 3 KW capacity
 - ◆ Allocation of 500 W average heat rejection
- **Inter-module ventilation**


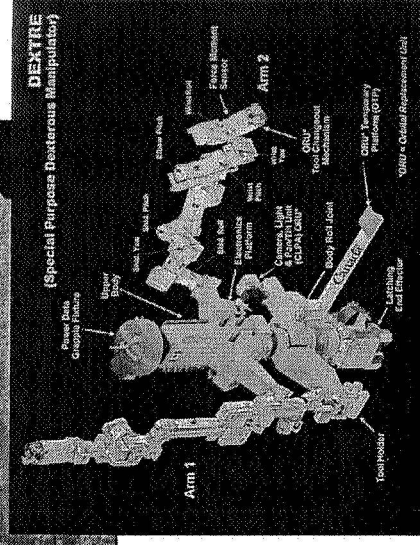


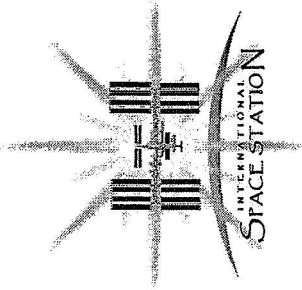
Typical Interfaces at CBM Vestibule

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- *ICCS external cargo must be compatible with ISS US Segment robotic systems and EVA handling*
- ◆ *SSRMS*
- ◆ *Special Purpose Dexterous Manipulator (SPDM/Dextre)*
- ◆ *Mobile Transporter*





Cargo Return & Disposal

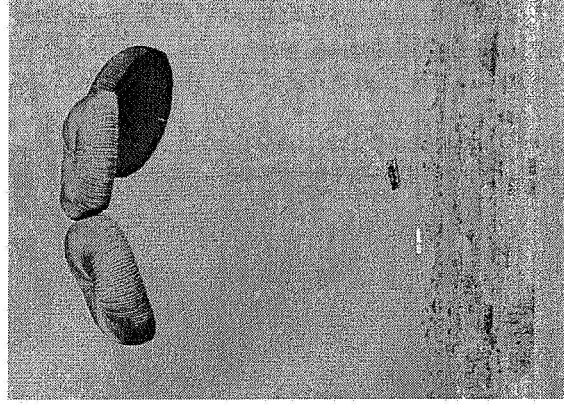
- **ICCS vehicles must have the capability to safely return cargo to Earth**

- ◆ Internal cargo: 11 MT/yr max, 1 MT/yr min
- ◆ External cargo: 3.3 MT/yr max, 0 min
- ◆ Return cargo delivery to NASA within 14 days of landing

☞ 4 hours for critical cargo

- **Cargo disposal required for large portion of ISS cargo**

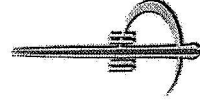
- ◆ Safe disposal requirements for expendable vehicles must be satisfied
- ◆ Internal cargo: 8.3 MT/yr max, 400 kg/yr min
- ◆ External cargo: 2.2 MT/yr max, 1400 kg/yr min

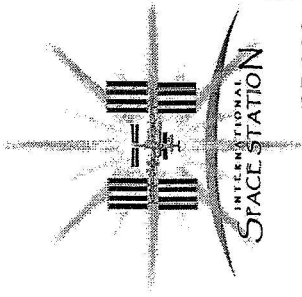


Cargo Recovery

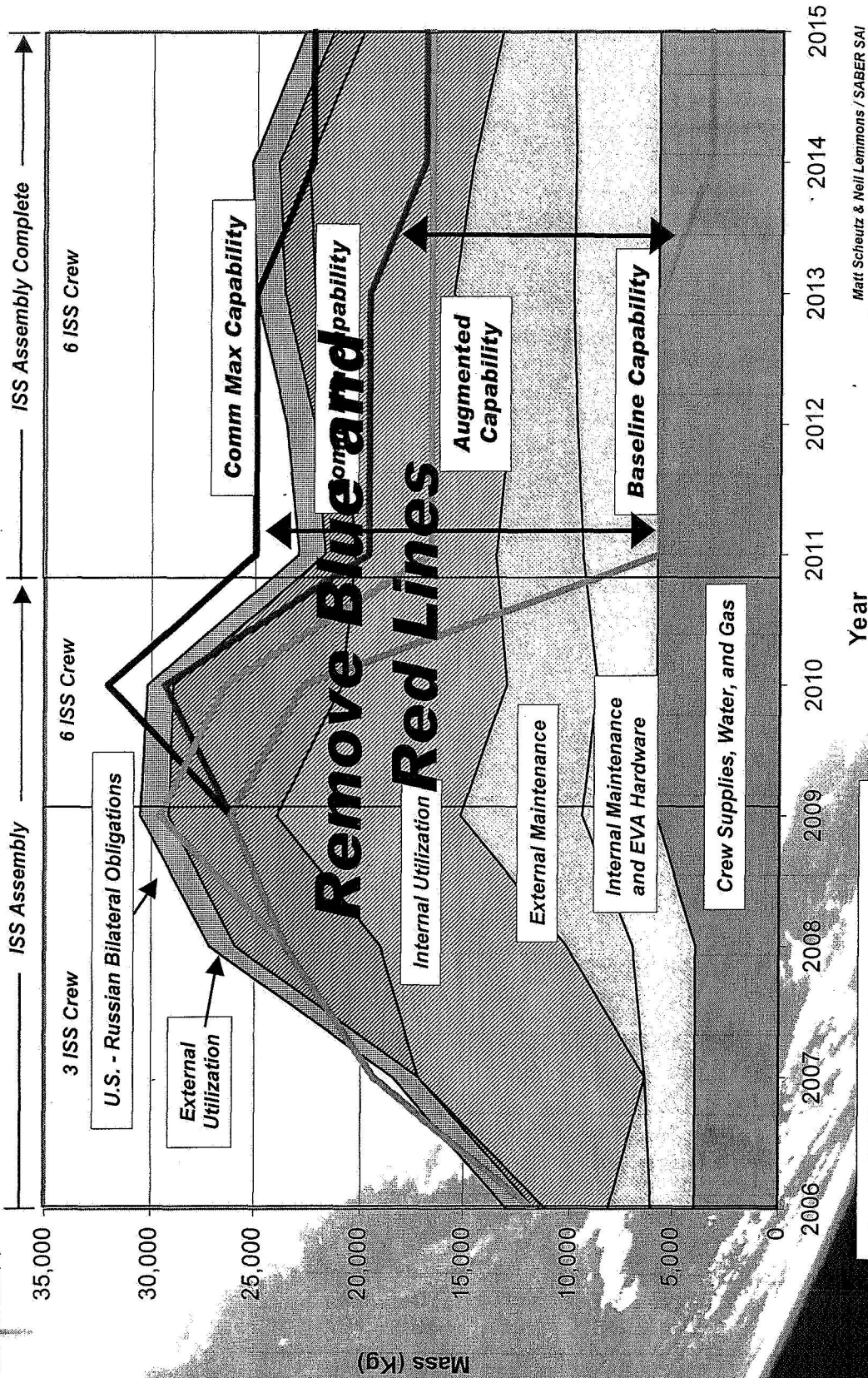


Destructive Entry





ISS Cargo Supply Balance

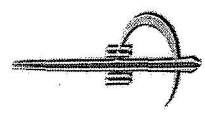


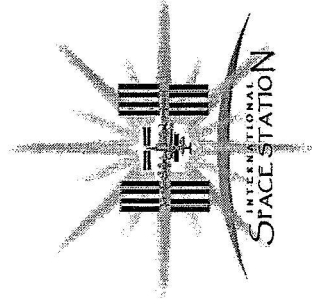
- Assembly Hardware is not included
- Accommodation masses are not included
- Crew rotation mass not included

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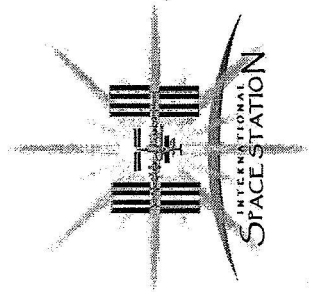
Philosophy

Maximum Cargo Requirements

- **ICCS maximum cargo requirements**
 - ◆ **Based on making up shortfall from baseline partner cargo delivery contribution**
 - ◆ **Includes latest available updates in need for crew supplies, maintenance, utilization, gas, & water**
 - ☞ New NASA ISS USOS utilization requirements official update expected in coming weeks from ESMD – preliminary requirements received recently
- ◆ **Return Cargo**
 - ☞ Maximum return capability of ~15,000 kg/yr

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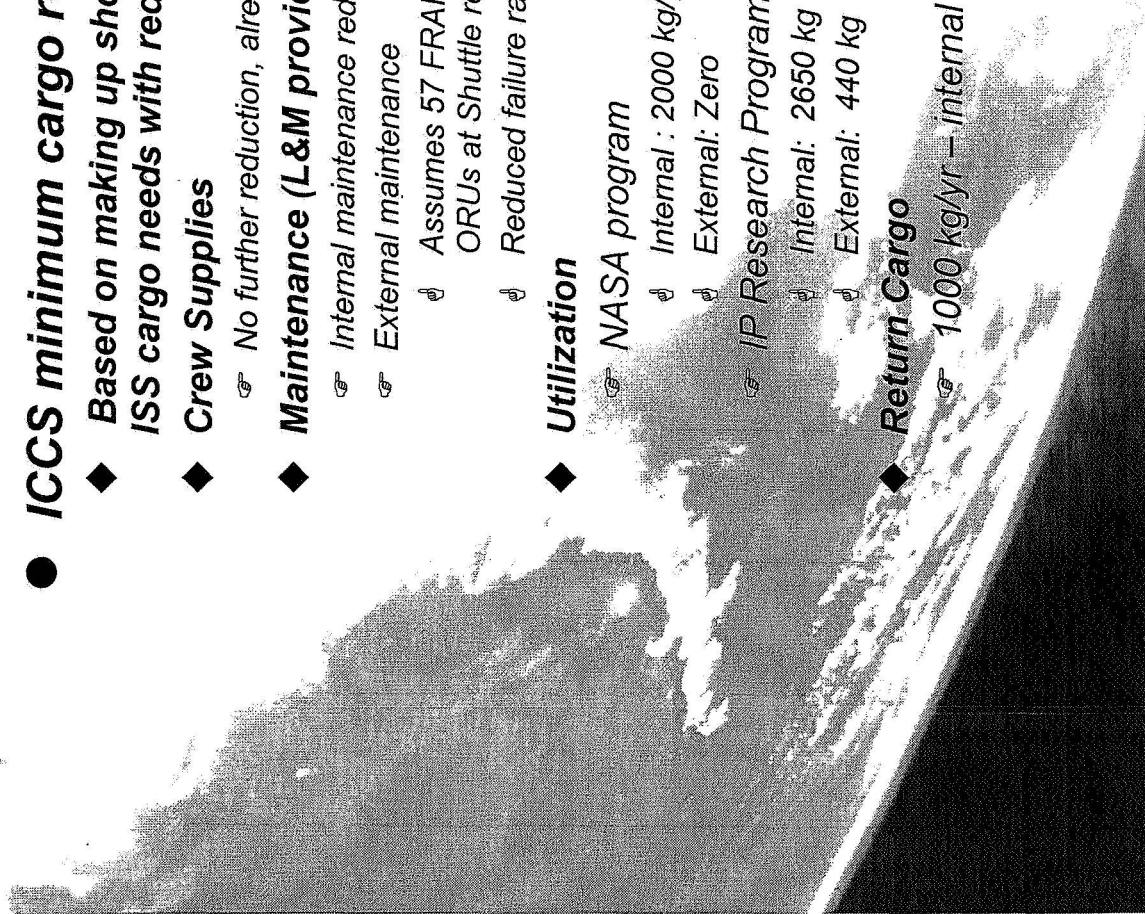
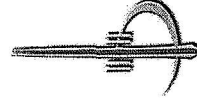


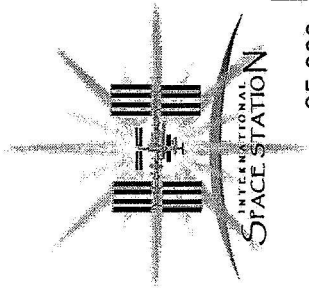
Philosophy

Minimum Cargo Requirements

- **ICCS minimum cargo requirements**
 - ◆ Based on making up shortfall from baseline partner contributions and ISS cargo needs with reductions in maintenance & utilization
 - ◆ **Crew Supplies**
 - ☞ No further reduction, already at minimum acceptable level
 - ◆ **Maintenance (L&M provided minimum requirement)**
 - ☞ Internal maintenance reduced 20%
 - ☞ External maintenance
 - ↓ Assumes 57 FRAM Eq of pre-positioned maintenance/spare ORUs at Shuttle retirement
 - ↓ Reduced failure rates
 - ◆ **Utilization**
 - ☞ NASA program
 - ↓ Internal : 2000 kg/yr internal cargo delivery
 - ↓ External: Zero
 - ☞ IP Research Program
 - ↓ Internal: 2650 kg
 - ↓ External: 440 kg
 - ◆ **Return Cargo**
 - ☞ 1000 kg/yr – internal cargo only

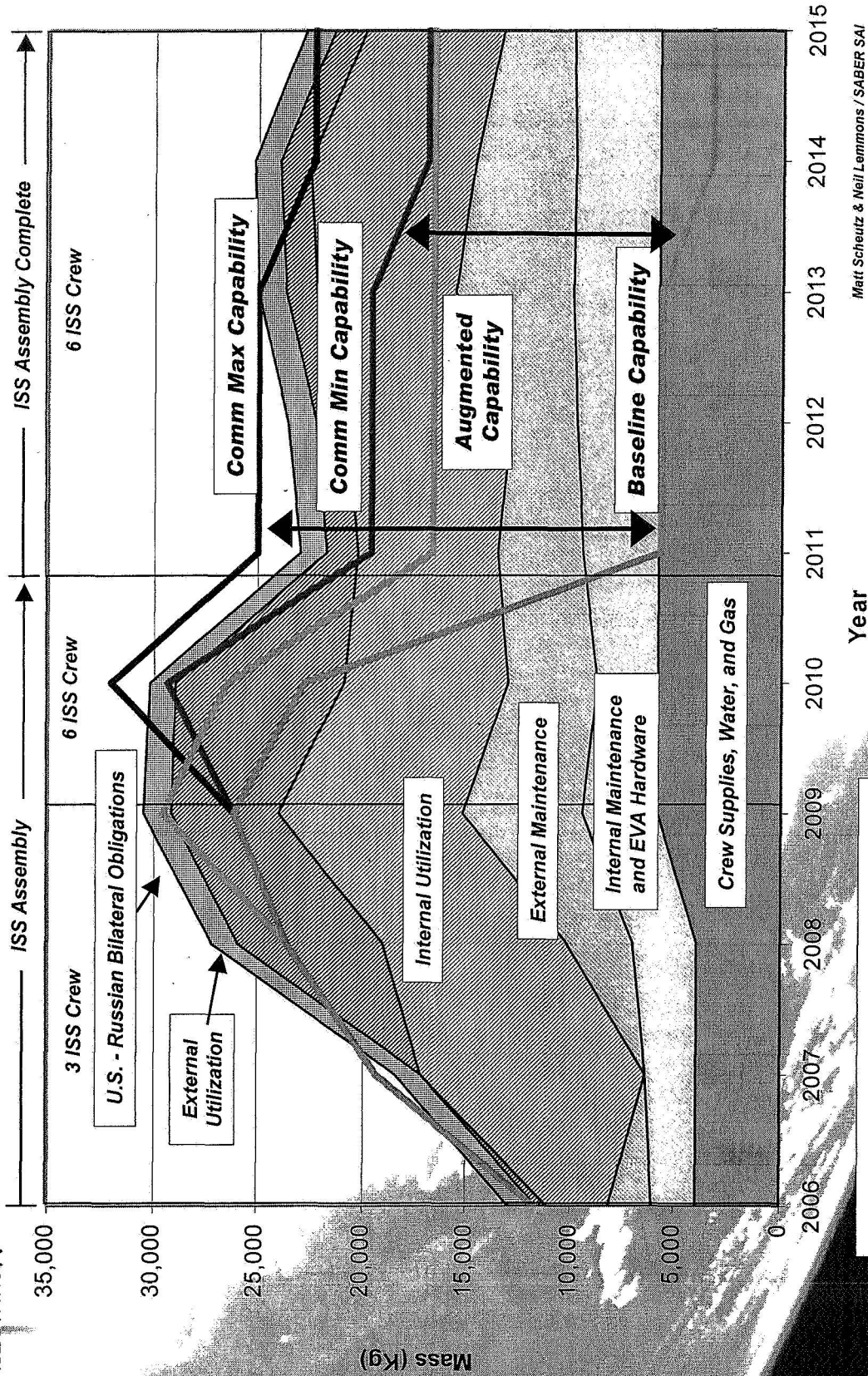
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Cargo Demand/Delivery Balance Summary



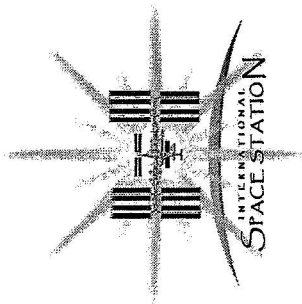
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- Accommodation masses are not included
- Crew rotation mass not included

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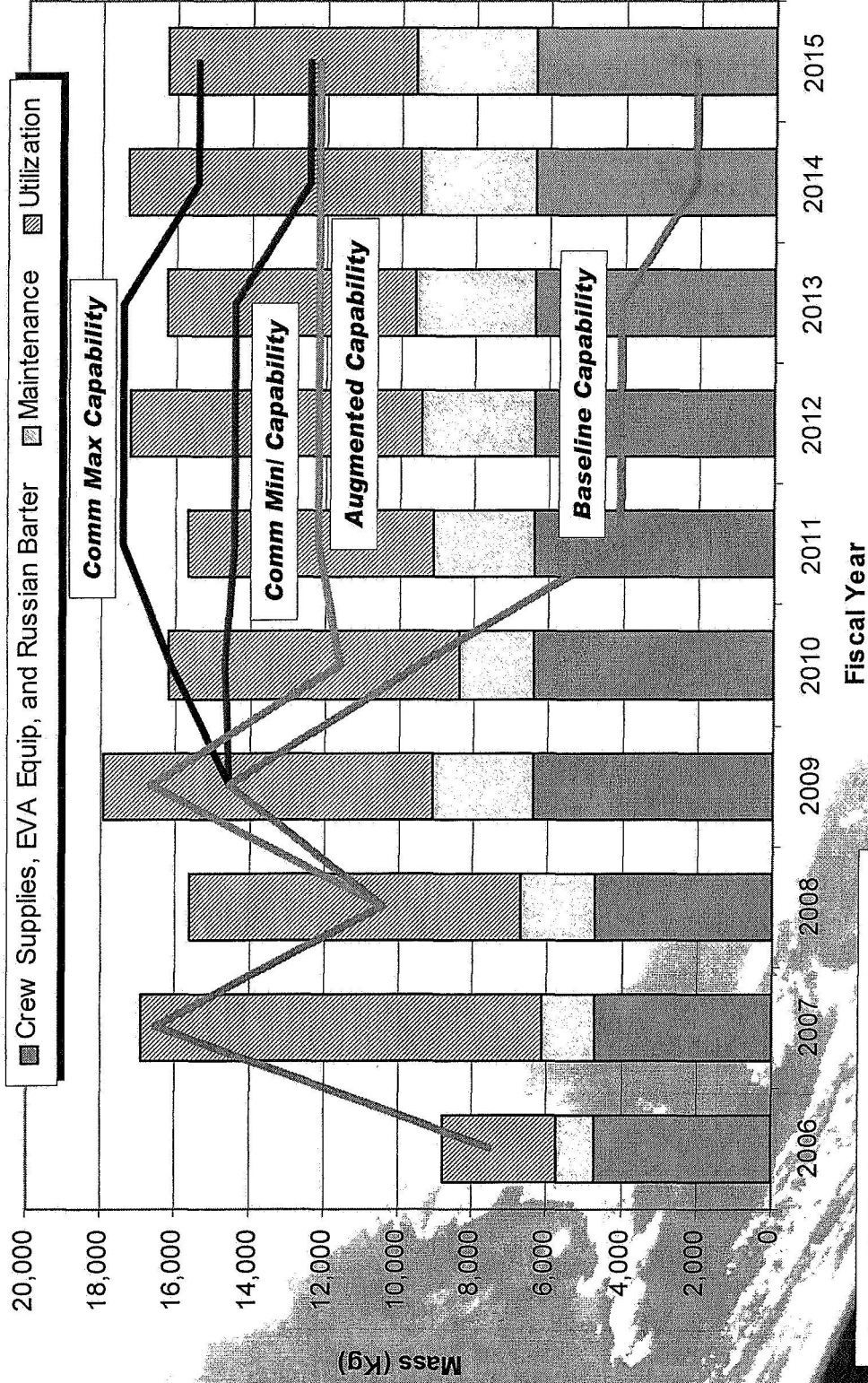
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ISS NASA/JAXA/ESA/CSA Cargo Internal Demand/Delivery Balance

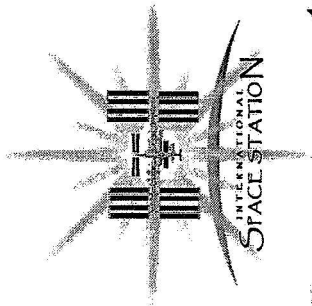


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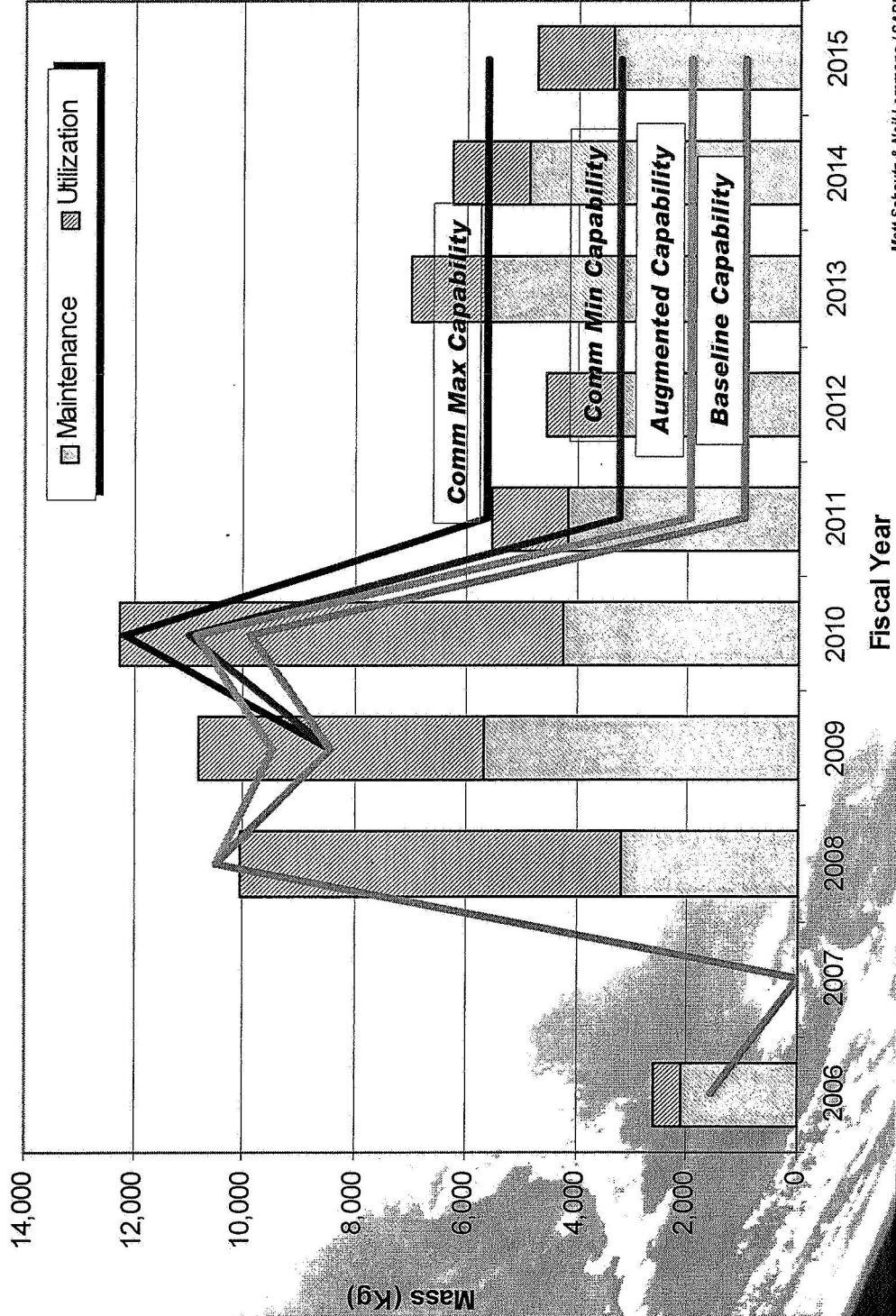
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ISS NASA/JAXA/ESA/CSA Cargo External Demand/Delivery Balance



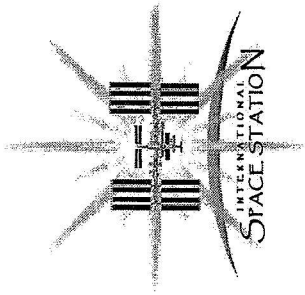
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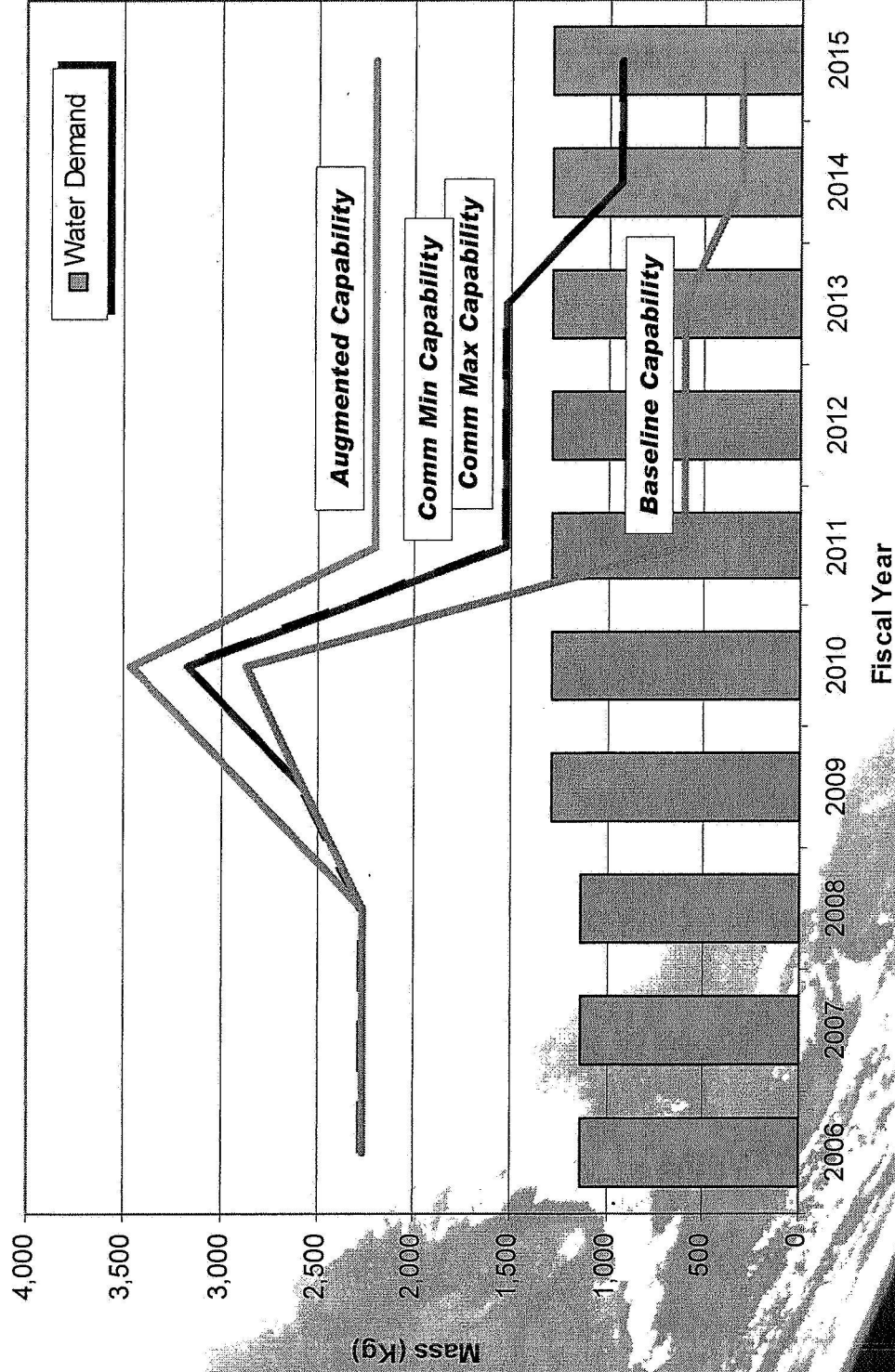
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ISS NASA/JAXA/ESA/CSA Cargo Water Demand/Delivery Balance



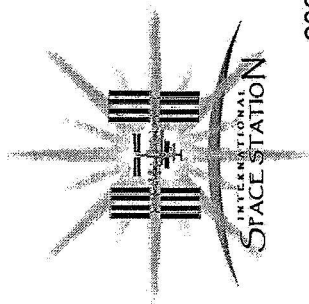
•Accommodation masses are not included

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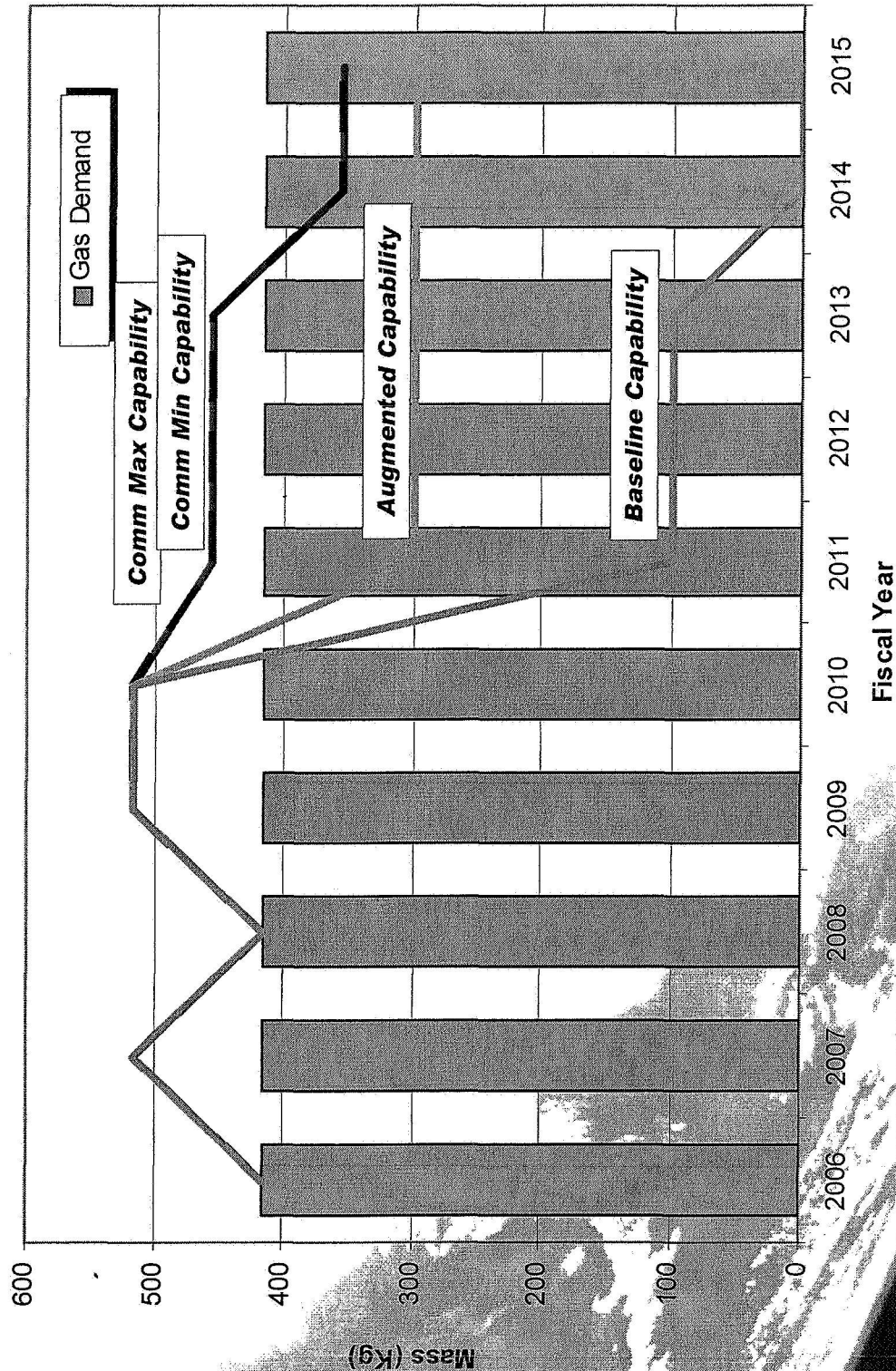
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ISS NASA/JAXA/ESA/CSA Cargo Gas Demand/Delivery Balance



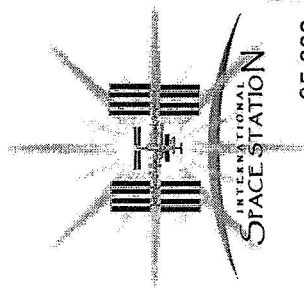
•Accommodation masses are not included

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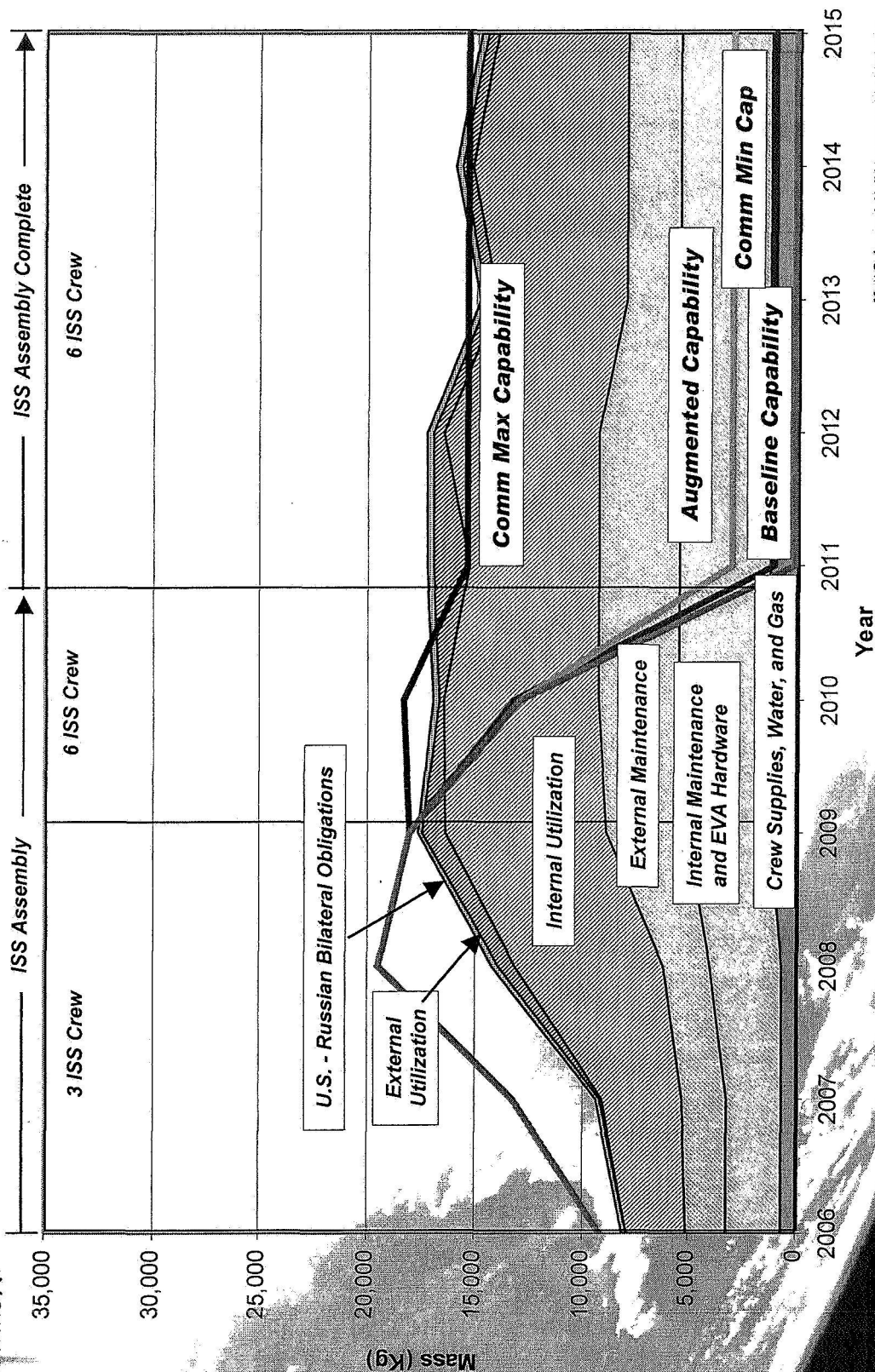
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ISS NASA/JAXA/ESA/CSA Cargo Return Cargo

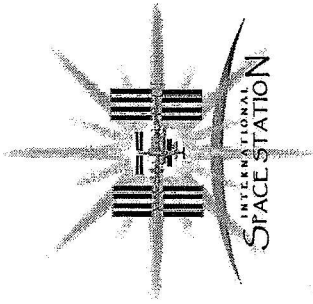


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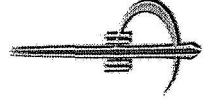
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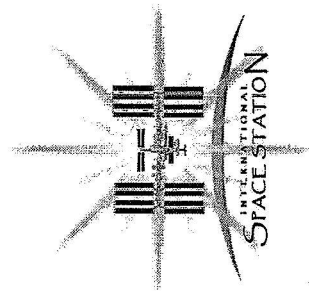


Key ICCS Requirements Summary

ISS Commercial Cargo Service Requirements Summary	Cargo Delivery				Return Cargo			
	Internal Cargo (MT/Yr)	External Cargo (MT/Yr)	Water (MT/Yr)	Gas (MT/Yr)	Recoverable		Disposable	
					Internal (MT/Yr)	External (MT/Yr)	Internal (MT/Yr)	External (MT/Yr)
Max Requirements	13.4	4.5	0.8	0.4	11	3.3	8.3	2.2
Min Requirements	10.4	2.2	0.8	0.4	1	0	0.4	1.4
Parameter	Launch On Need	Flight Rate	Dock Berth	Stay Time	Power	Late Access	Early Access	EVA & Robotic Capability
Requirement	180 Days	≤ 6 yr	US Segment	≥ 7 Days	500 W AV 1500 W PK	Launch: 19 H/s 200 kg 2 m ³	Launch: 4 H/s 200 kg 2 m ³	Yes

DRAFT





Conclusion

- **The fundamental requirements necessary to begin acquisition of an ISS Commercial Cargo Service are complete**
 - ◆ The "ICCS Commercial Maximum" satisfies current projections for NASA/JAXA/ESA/CSA cargo delivery demand
 - ◆ The "ICCS Commercial Minimum" may be acceptable if key risk areas have optimistic outcomes and utilization cargo need is substantially reduced
- **ICCS requirements revision planned after official utilization requirements update -- expected in coming weeks**

